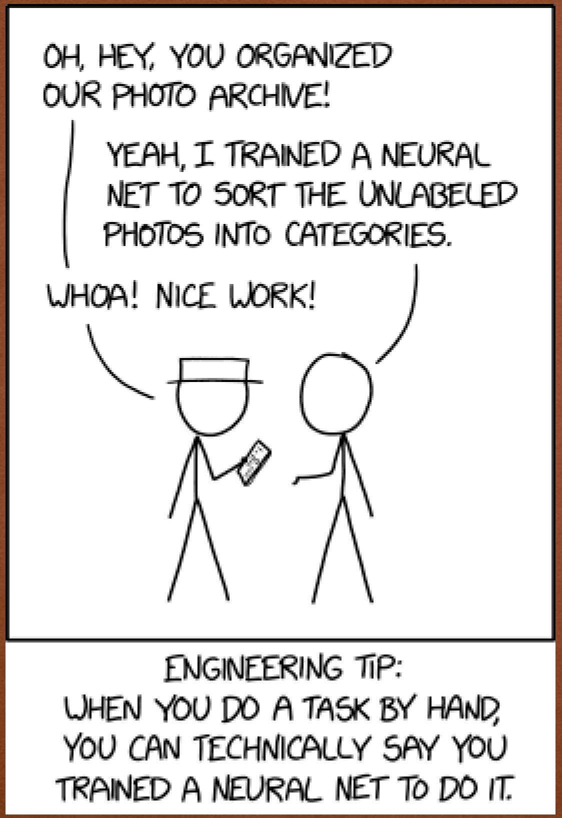
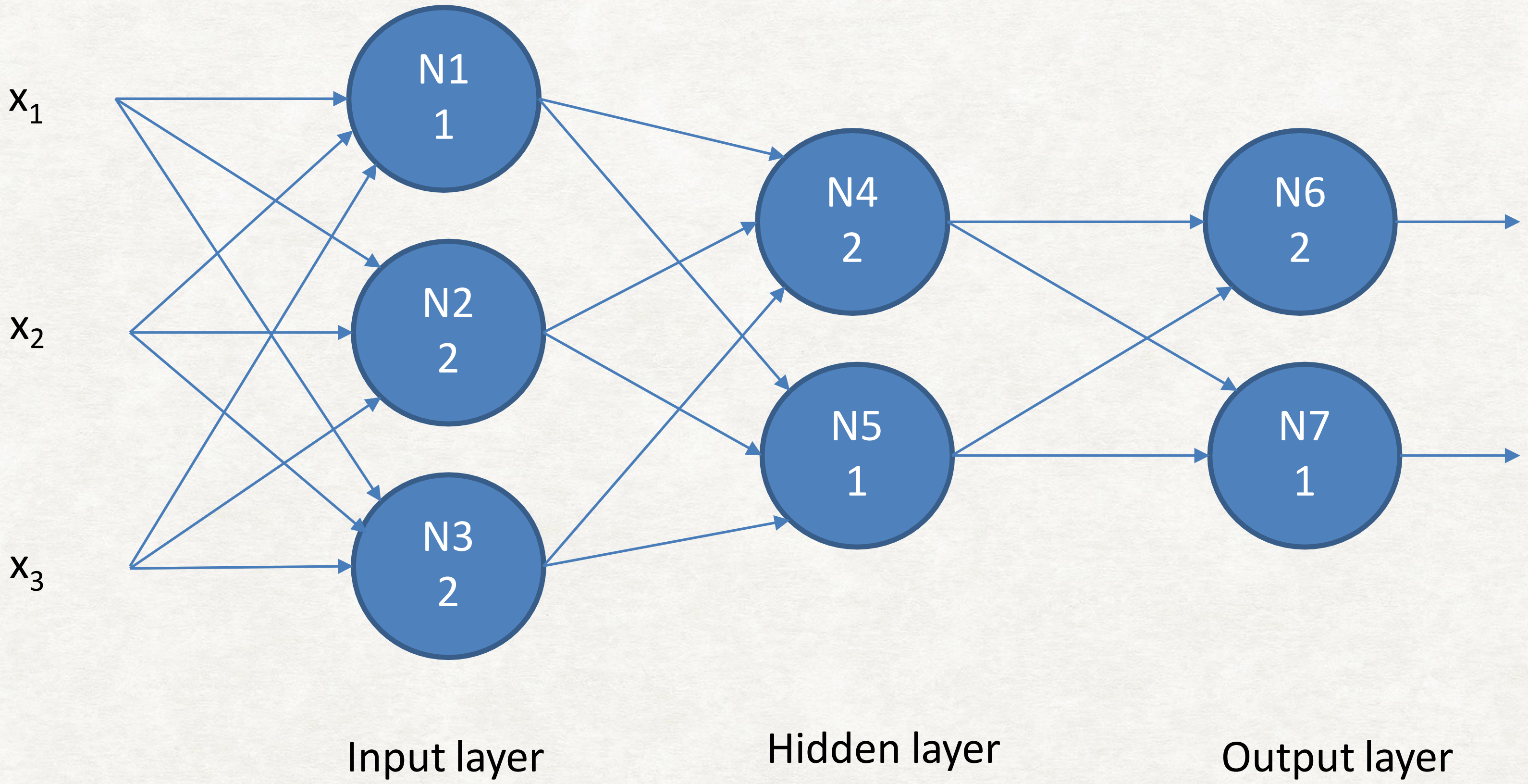
Artificial Intelligence

Chapter 15

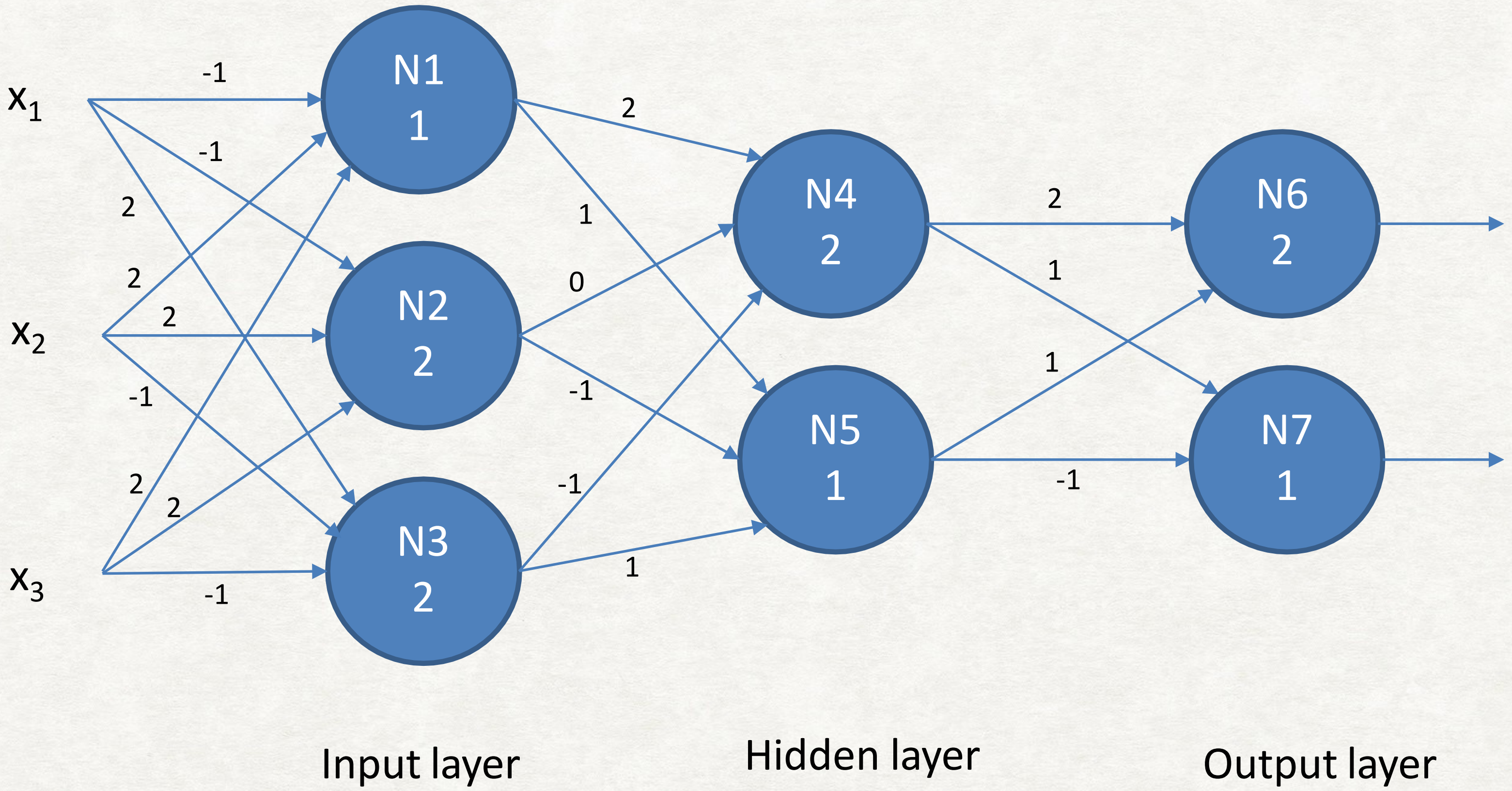


https://xkcd.com/2173/

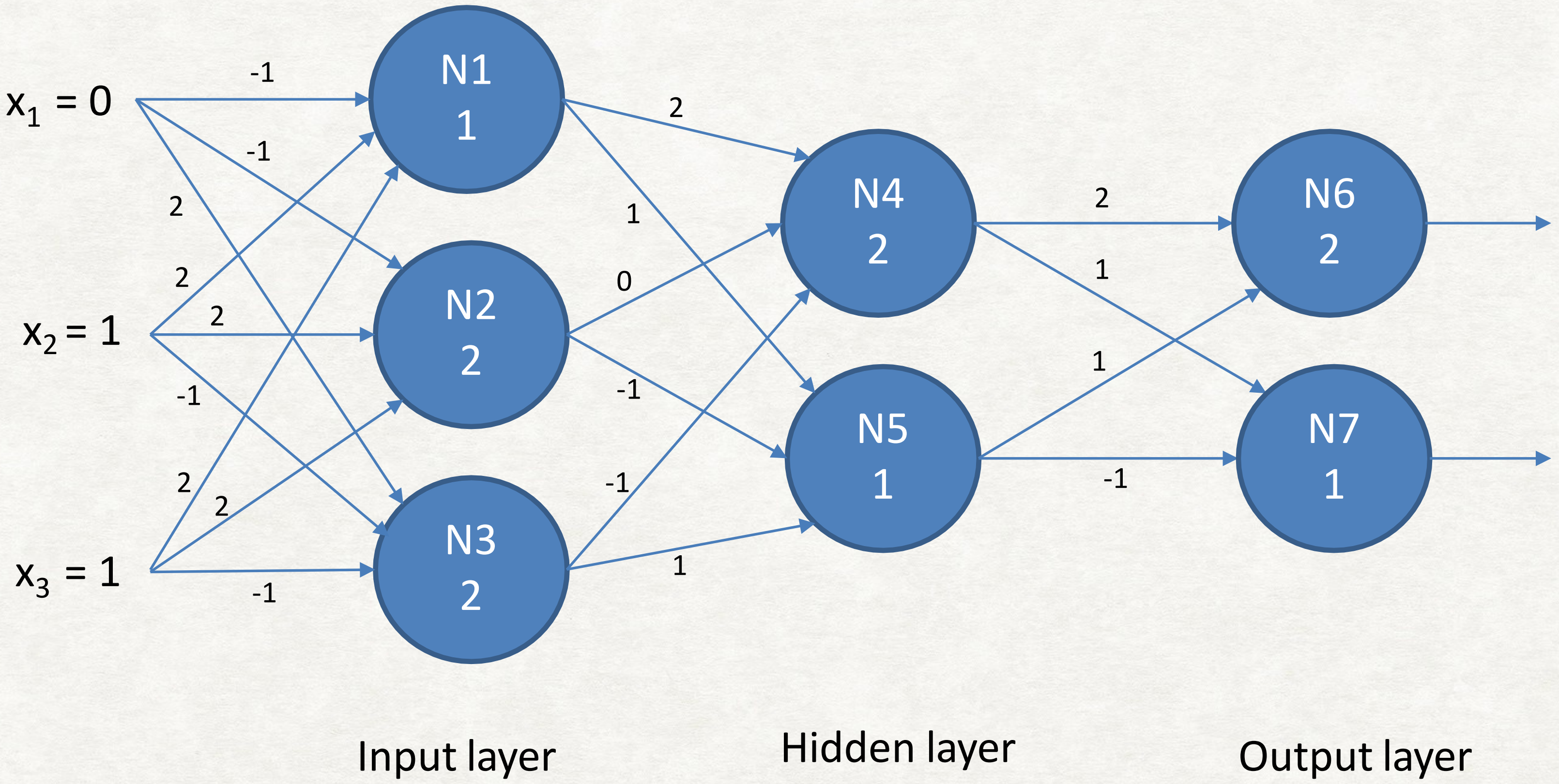
LET'S LOOK AT ANOTHER SIMPLE NEURAL NETWORK



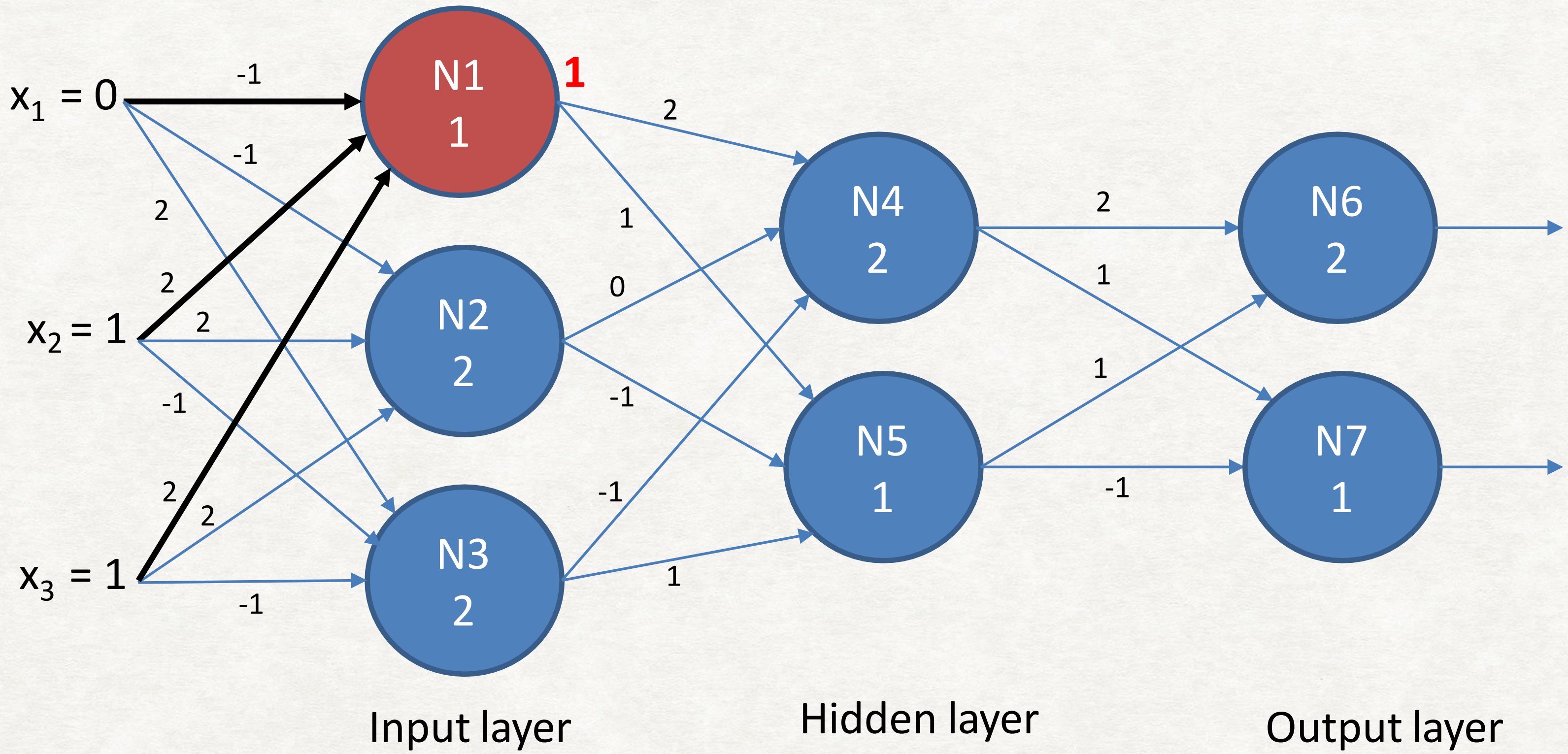
LET'S ADD WEIGHTS



LET'S APPLY INPUT

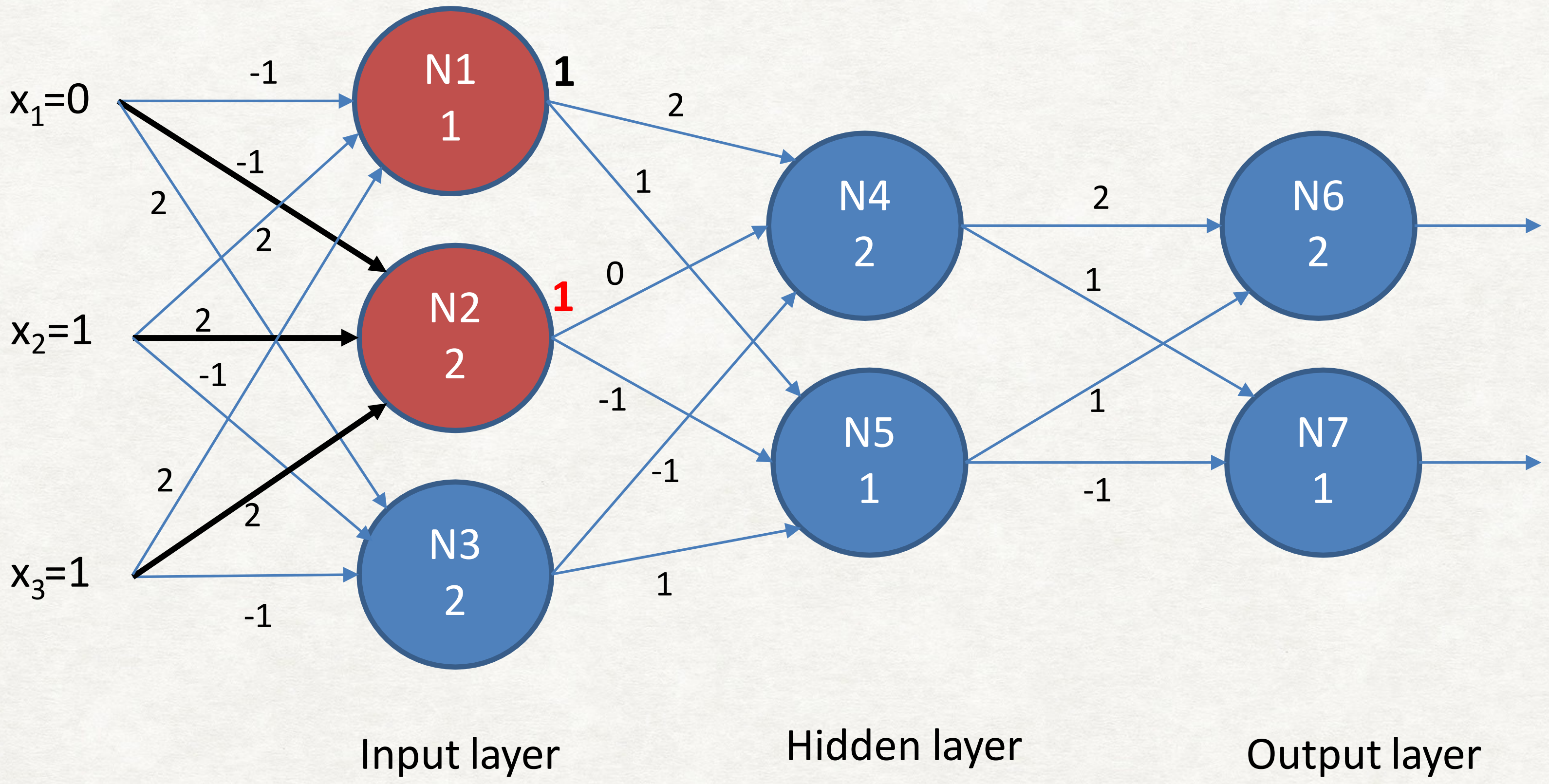


FORWARD PROPAGATION



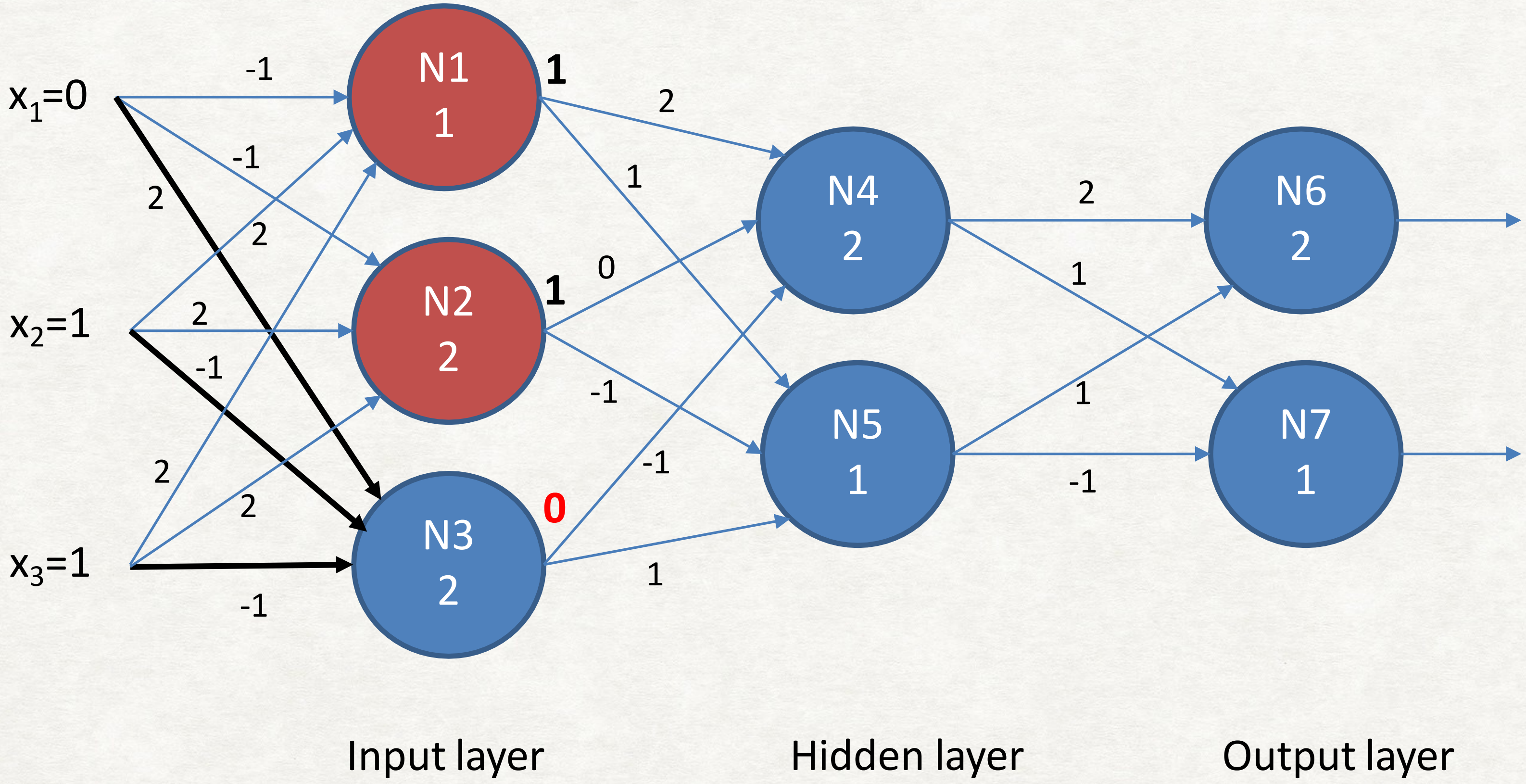
$$0 \times(-1) + 1 \times(2) + 1 \times(2) = 4 \geq 1 \rightarrow \text{neuron N1 fires}$$

FORWARD PROPAGATION



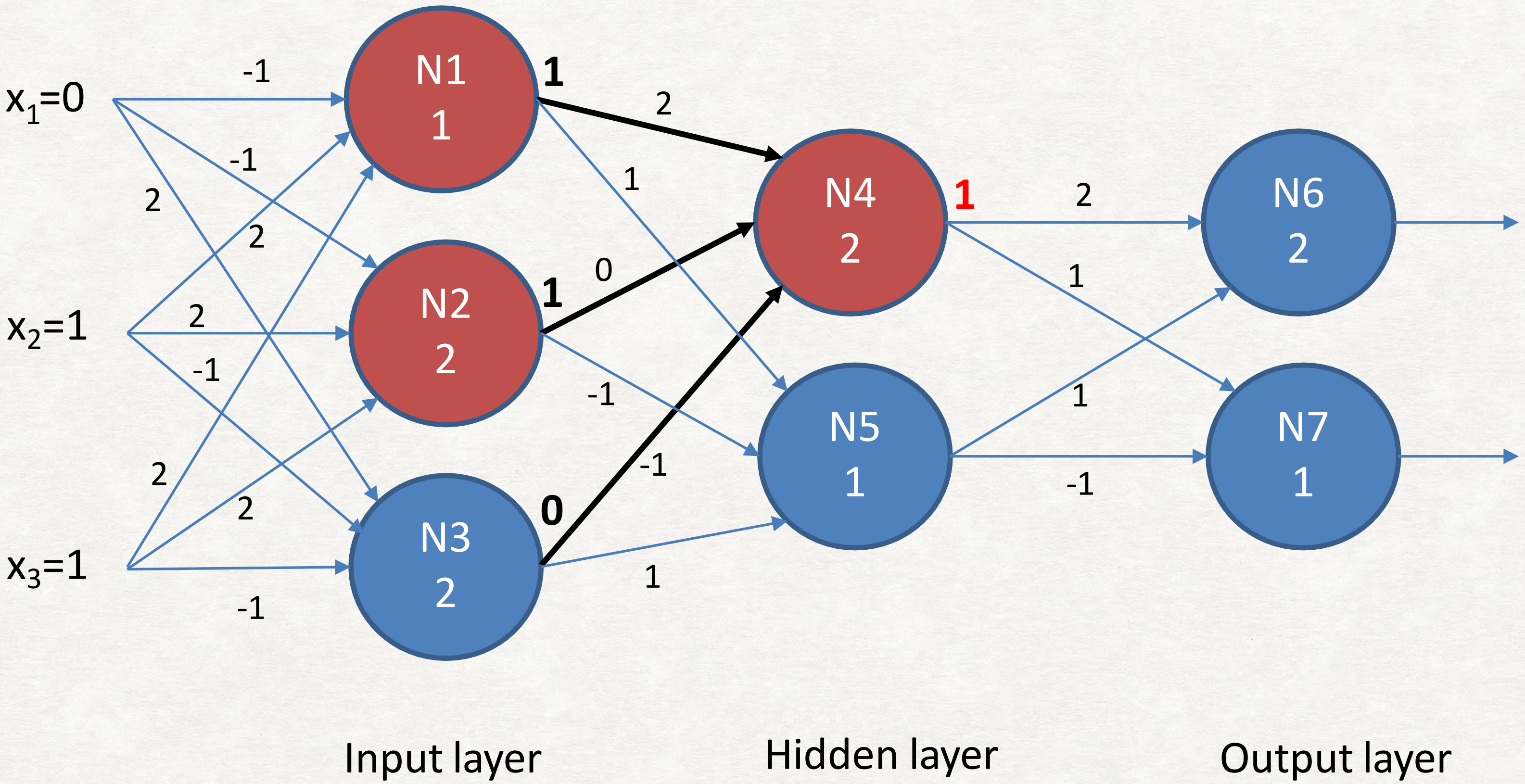
0*(-1) + 1*2 + 1*2 = 4 >= 2: neuron N2 fires

FORWARD PROPAGATION



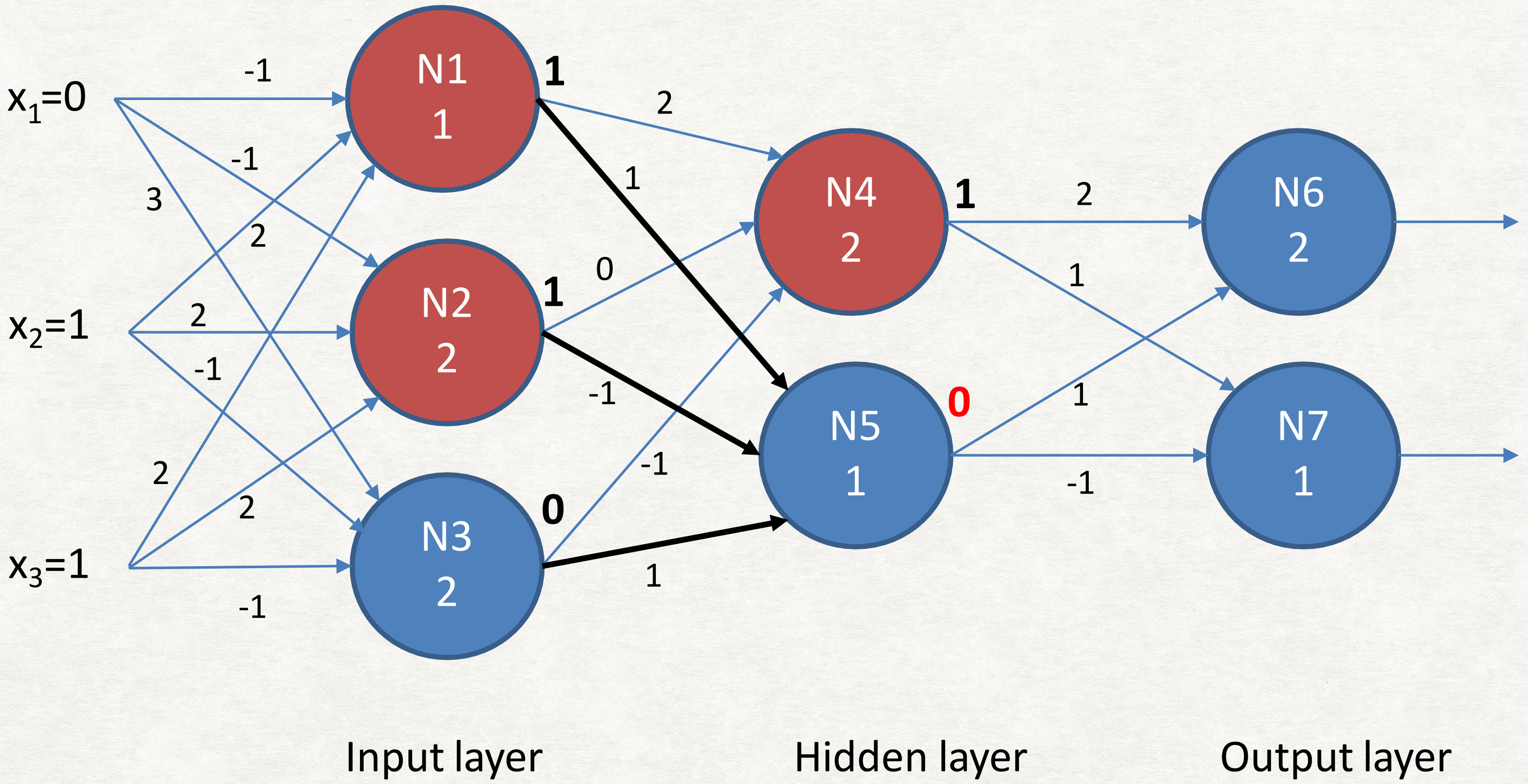
0*2 + 1*(-1) + 1*(-1) = -2 < 2: neuron N3 doesn't fire

FORWARD PROPAGATION



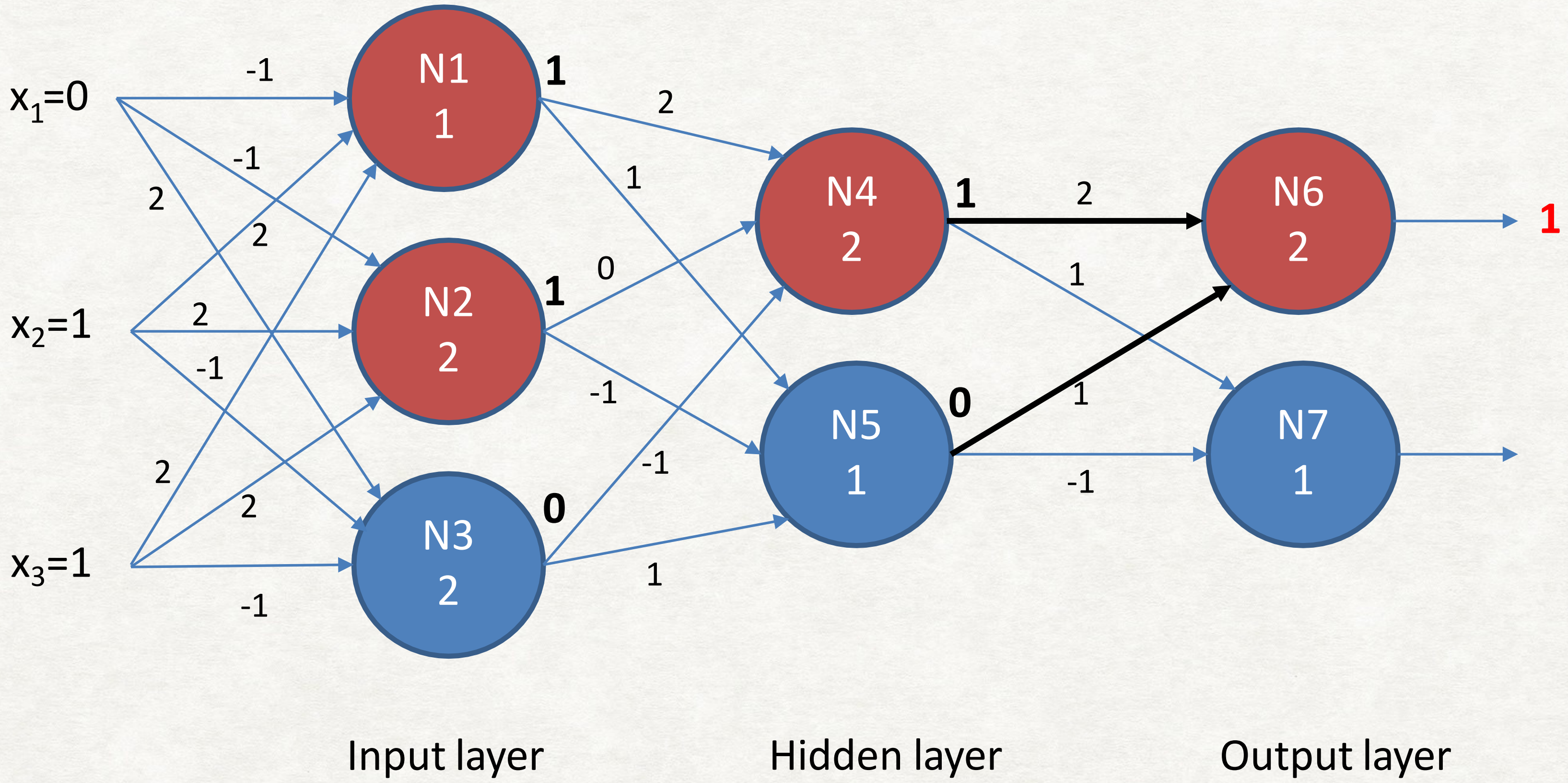
1*2 + 1*0 + 0*(-1) = 2 >= 2: neuron N4 fires

FORWARD PROPAGATION



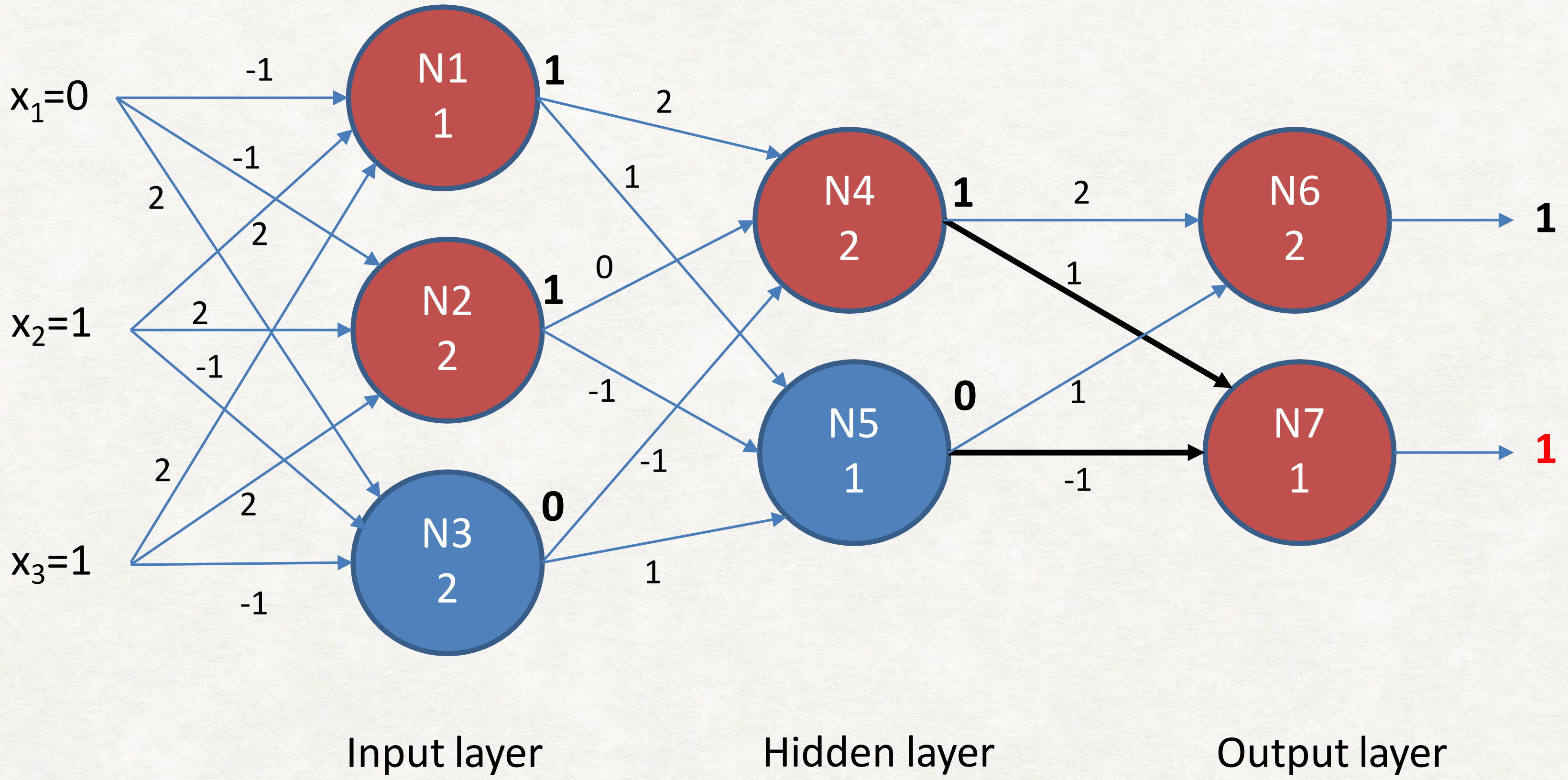
1*1 + 1*(-1) + 0*1 = 0 < 1: neuron 5 doesn’t fire

FORWARD PROPAGATION



1*2 + 0 * 1 = 2 >= 2: neuron 6 fires

FORWARD PROPAGATION



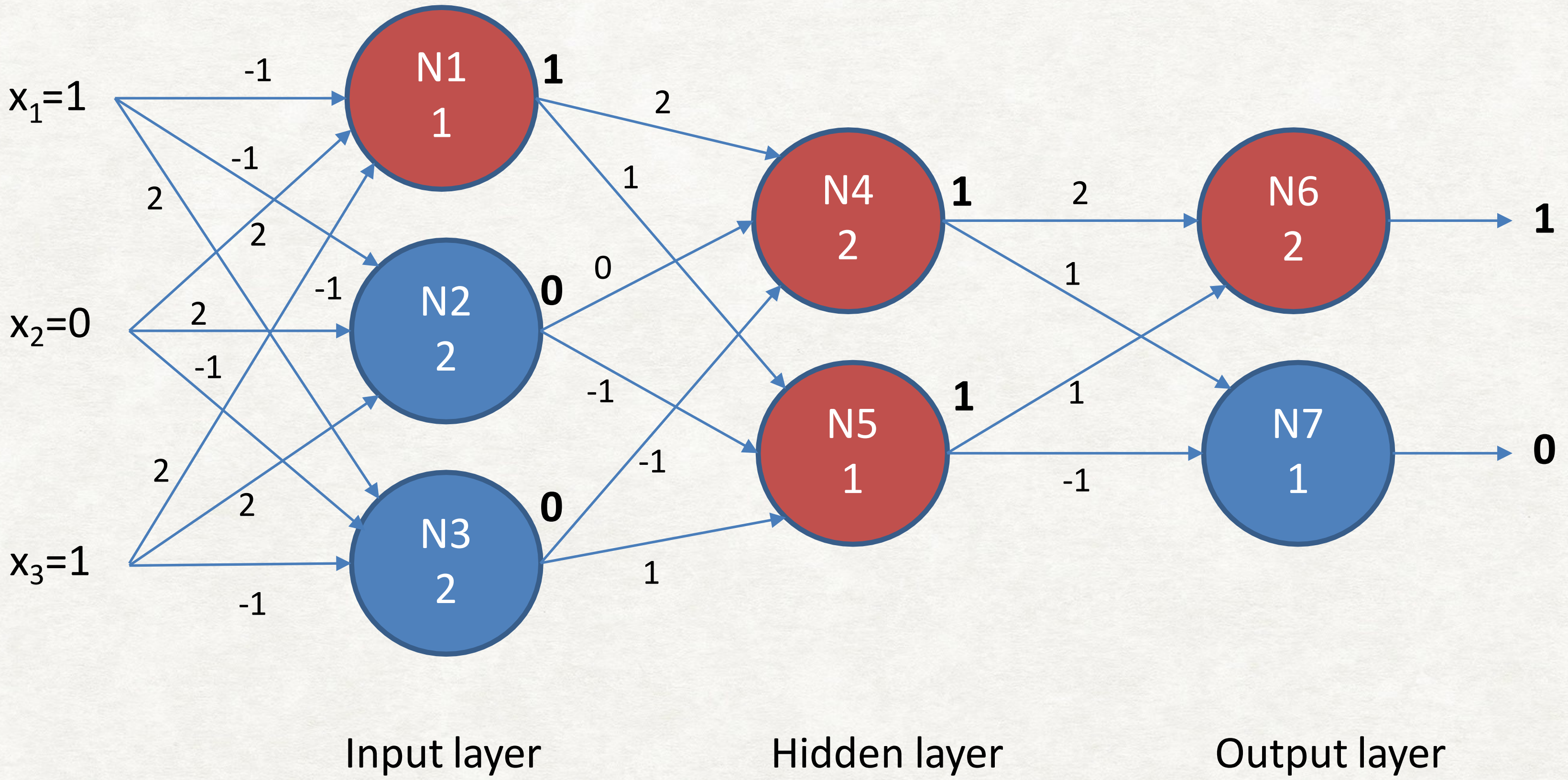
1*1 + 0 * (-1) = 1 >= 1: neuron 7 fires

TAKING STOCK

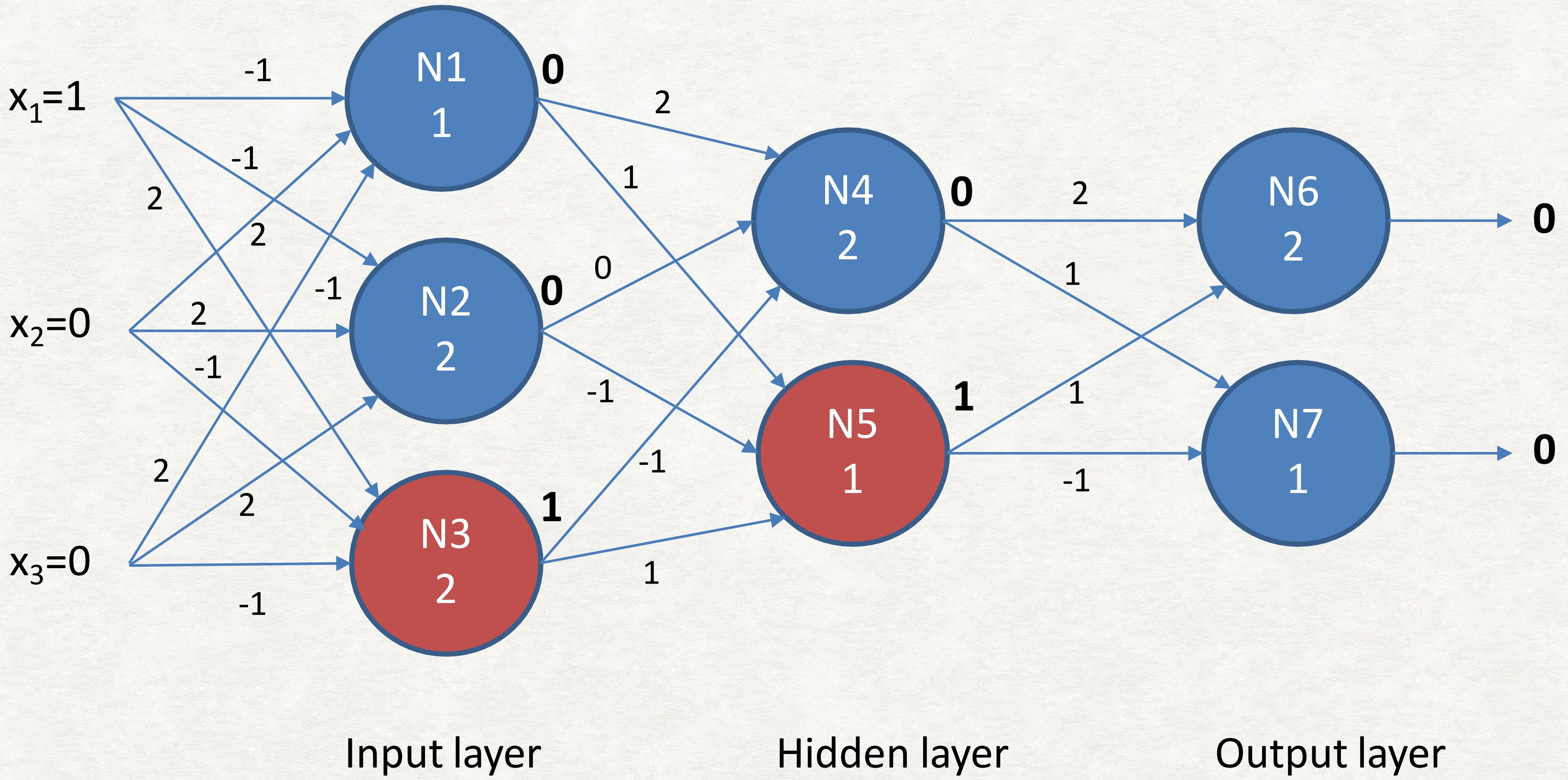
Even a simple neural network like this is relatively complicated (19 connection weights).

Different input results in different output – but the output is difficult to predict from the input!

LET'S APPLY A DIFFERENT INPUT



LET'S APPLY DIFFERENT INPUT AGAIN



WHERE ARE NEURAL NETWORKS USED?

Almost everywhere in AI

- Speech recognition
- Video and image processing
- Self-driving cars and robots
- Recommender systems
- Medical Diagnosis
- Natural Language Processing
- … and many more areas

“Deep learning” in uses “deep” neural networks (several hidden layers).

- DeepFace used by Facebook to recognize human faces in digital images
  - It uses a **9-layer** neural network with over **120 million connection weights**.
  - The neural network was trained on **4 million images** uploaded by Facebook users.
- DeepFace reaches an accuracy of 97.35% ± 0.25% where human beings have 97.53%.

SUMMARY ON NEURAL NETWORKS SO FAR

There can be any number of layers and any number of neurons.

Neurons from one layer feed their output into one or more inputs of the subsequent layer.

With a different set of weights, the results can (and typically will) look completely different.

"Serious" neural networks have a very large number of neurons (hundreds or even thousands).

TRAINING A NEURAL NETWORK

E.g. to decide whether an image contains a person, a dog, a cat or nothing

- Input: image data (feature vector)
- Output: two outputs such that 1 1 means human, 1 0 means dog, 0 1 means cat, and 0 0 means no such creature

Start with a training data set of images for which the correct (desired) outputs are known (e.g., 1000 images of people, 1000 images of dogs, 1000 of cats, 1000 of other things).

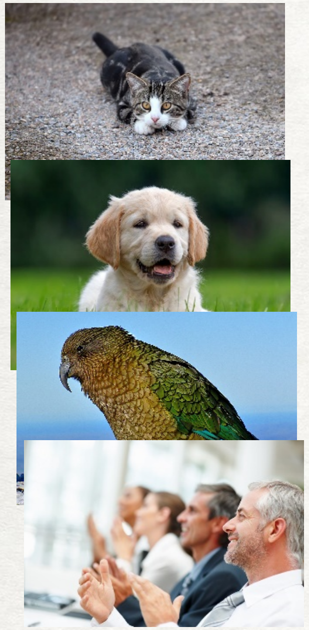
- Initial weights can be random.

Apply input and inspect output.

- If the output is the correct classification, do nothing and apply the next training image.
- If the output is incorrect, run a ***back propagation algorithm***.

https://www.youtube.com/watch?v=bfmFfD2RIcg

TRAINING A NEURAL NETWORK

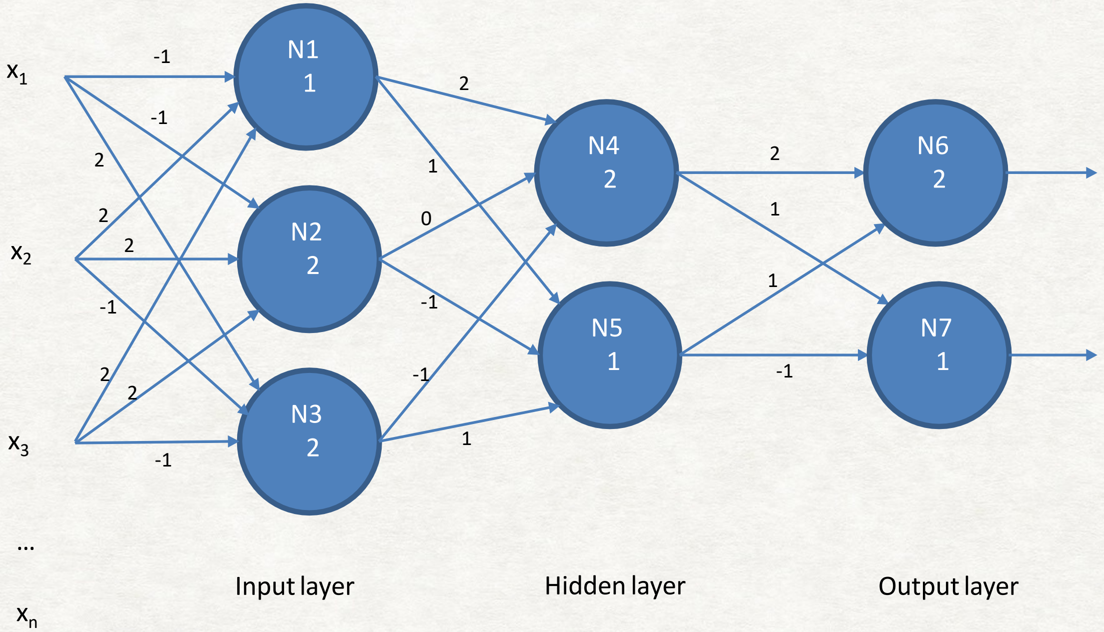


Cat

Dog

Other

Human



Error = difference between expected output and current output for the training image

- ➢ Training a neural network = optimising the weight values to minimise the error on the training set.

BACK PROPAGATION ALGORITHM

1. Compute the error in the network by measuring the difference between the current output vector of the network and the desired output vector.

2. If a neuron fires when it should not have, adjust its weights such that
   positive (excitatory) weights are decreased.
   negative (inhibitory) weights are increased.

2. If a neuron does not fire when it should have, adjust its weights such that
   positive (excitatory) weights are increased.
   negative (inhibitory) weights are decreased.

3. Pass back information on the error to the neurons in the previous layer.

4. These neurons keep an error count and estimate how much they contribute to the error.

5. These estimates are used to adjust the weights for the inputs in that layer, and error information is sent to the neurons in the layer before that, etc.

A TRAINED NEURAL NETWORK

- Eventually, all weights are adjusted to the point where the network can correctly classify the training data set – it has “learned”.
- We can now use the network to classify images it hasn’t seen before.
- If we can give the network feedback on what it has and has not classified correctly, the network can continue to learn.

ROBOTS

A robot is a physical device that has the ability to take in sensory data from its environment (though not always) and to autonomously perform mechanical actions of some sort in response.

The word "robot" comes from the Czech word *robota* meaning slave-like labor. Robots are

Robots are used for tasks that:

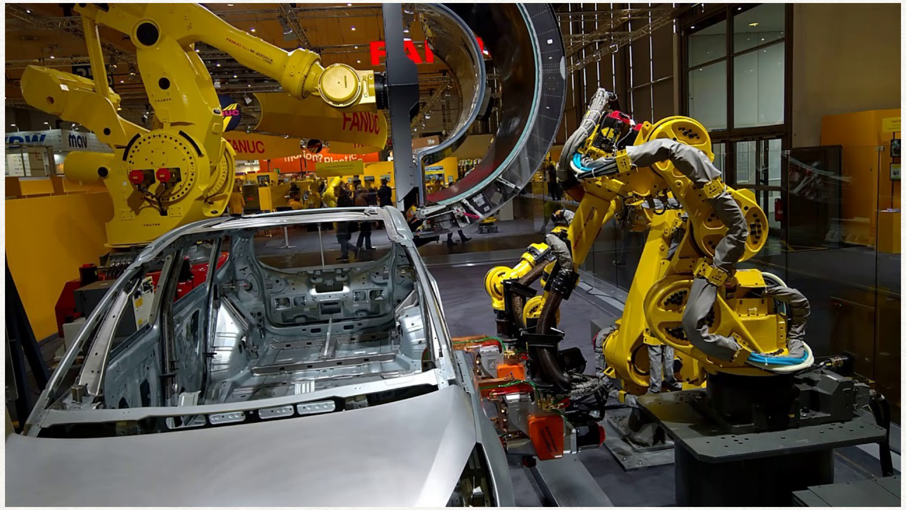
- humans cannot do, e.g., because of the precision required.
- humans find tedious.
- are repetitive or dangerous for humans.

They can usually do it:

- faster than humans.
- more reliably than humans.

https://blog.robotiq.com/whats-the-difference-between-robotics-and-artificial-intelligence

Tasks that robots can perform



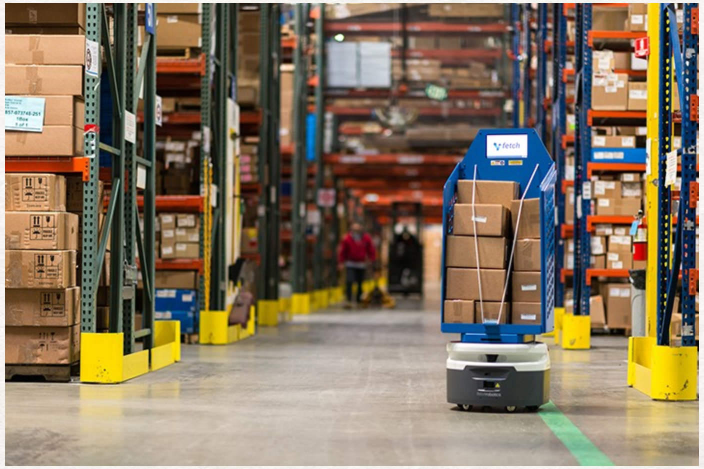
Robots welding car frames

Google’s self-driving car

Uber’s self-driving car

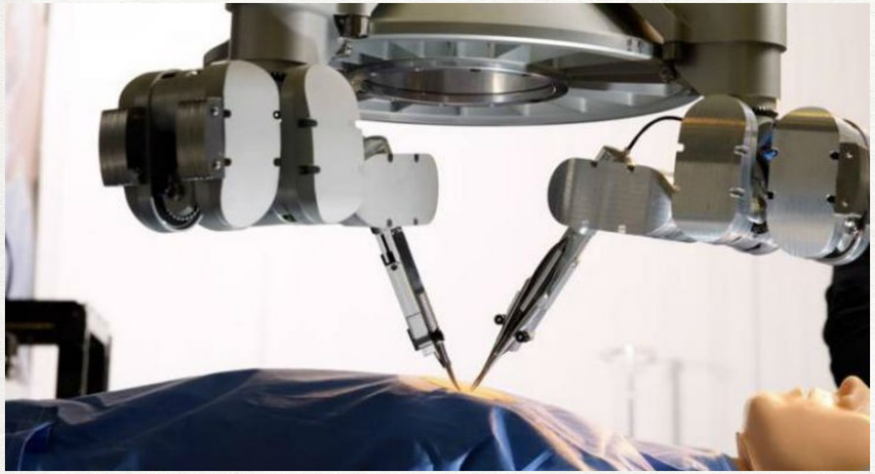
Tasks that robots can perform

Robots packaging food and drugs

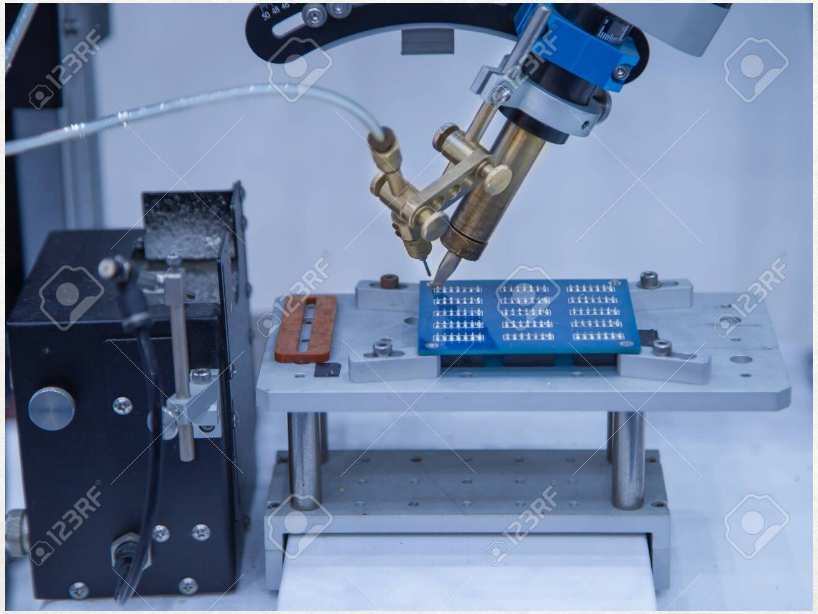


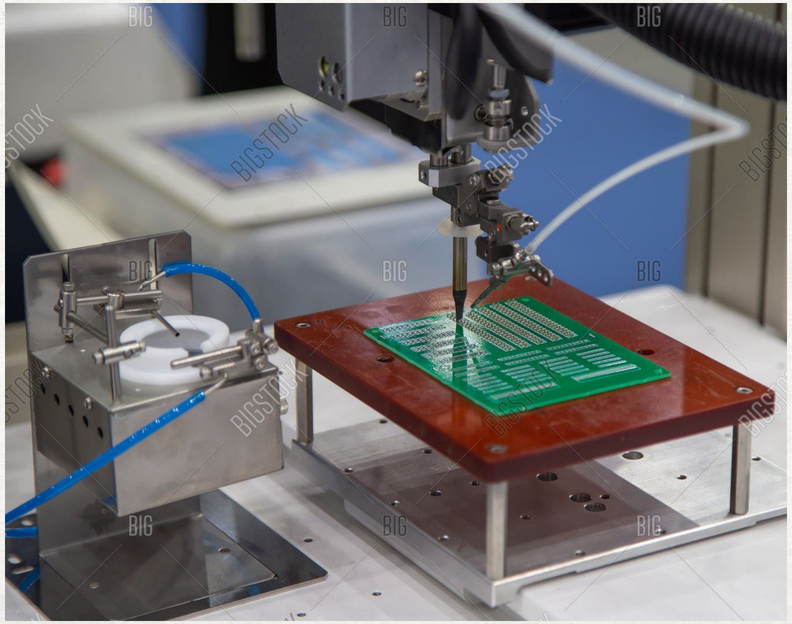
Fetching and packing items from warehouse storage

Tasks that robots can perform



Microsurgery

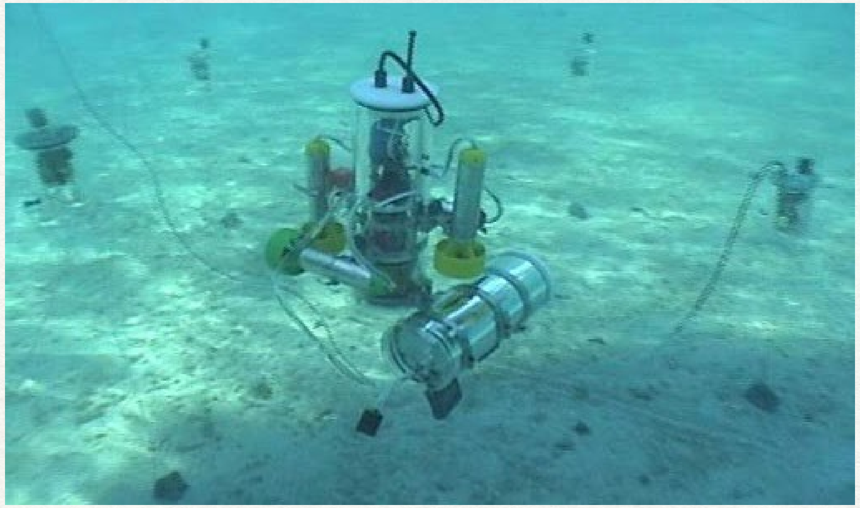




Soldering wires
in circuits

Tasks that robots can perform

Bomb Disposal



Underwater Salvage

Space Exploration (Mars Rovers)

Emergency search and rescue

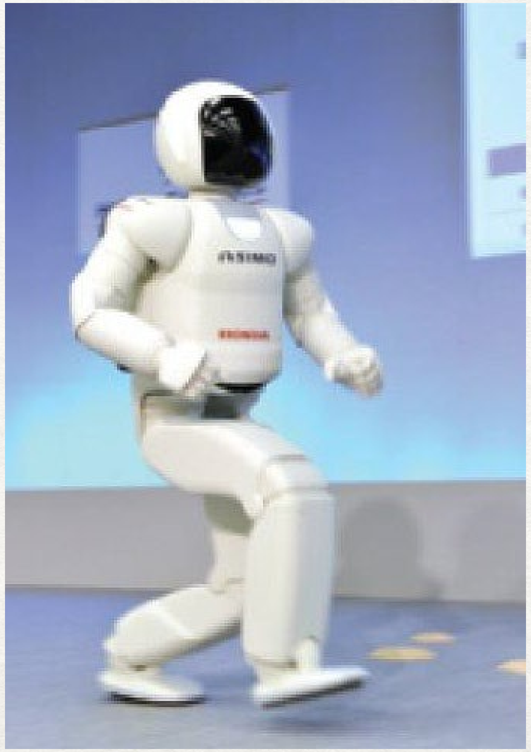
HUMANOID ROBOTS

Humanoid robots are designed for interacting with people

- Help elderly or hospital patients
- Monitor small children

Japan is a leader in humanoid robots

- Aging population needs support

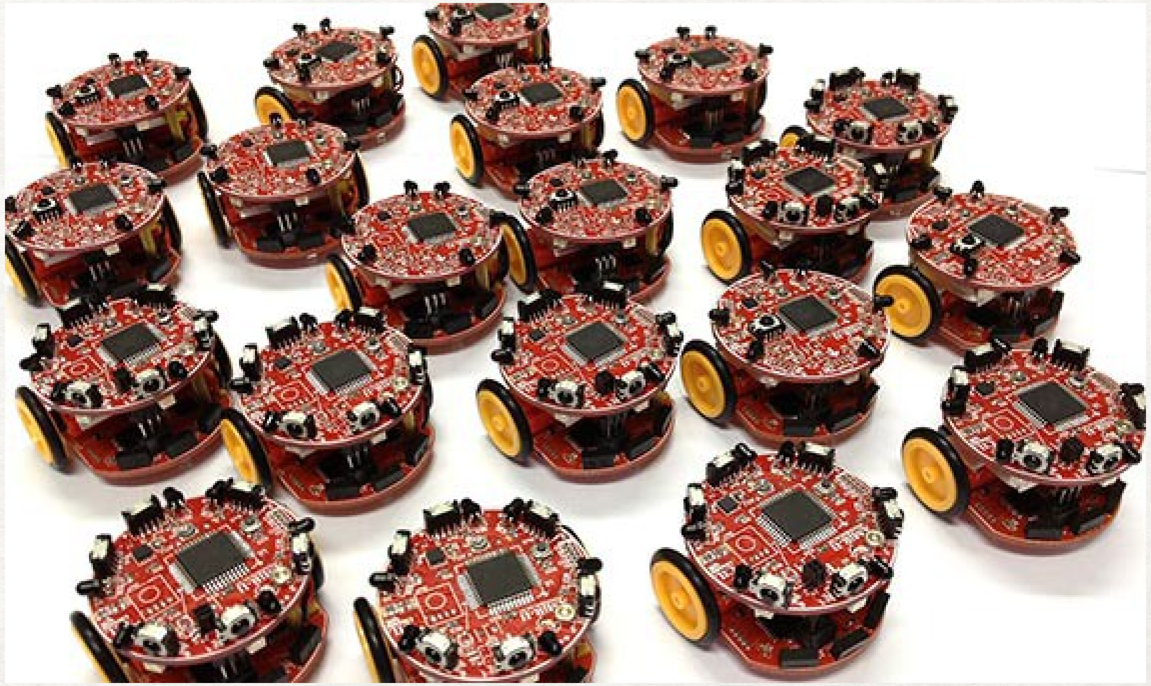


Honda's Asimo

- Designed to walk and move fluidly and robustly
- Can open/close a door to go through, serve refreshments, etc.

MULTIPLE COOPERATING ROBOTS

- Schools of robot fish for studying sea life.
- Swarms of robot flies for reconnaissance.
- Groups of robot snowmobiles to study climate change.



STRATEGIES FOR ROBOT CONTROL PROGRAMS

Reactive strategy

- Limit/eliminate internal model
- React immediately to sensory inputs
- Rapid cycle from inputs to responses to more inputs
- Much like the human “subconscious reactions”

Deliberative strategy

- Maintain detailed internal model of the world
- Reason about sensory inputs and choose best response
- Much like the human “conscious thought process”

FUN FACTS ABOUT ROBOTS

- The existence of Robots dates as far back as the 5th century with the creation of the mechanical dove by Archytas of Tarentum.
- A robot killed a factory worker in 1981. A robotic factory arm crushed an employee at the Kawasaki plant.
- Scientists are developing robots that will be able to plant seeds, weed, water, and spray without a farmer needing to do go into the field.
- A Nanobot is a microscopic robot that can be placed in the blood stream to perform delicate surgical procedures that are too difficult for standard surgery.
- Not every robot makes use of artificial intelligence. Some robots “learn” from their environment but not all.

DRONES

Unnamed Aerial Vehicle (UAV)

- Controlled by a computer on board or by a human at a remote site.
- Primarily used by military and law enforcement.

Uses of drones

Delivering medical supplies

Monitoring dangerous situations

USES OF DRONES

Agricultural-related aerial photography

Surveys of livestock or wildlife

USES OF DRONES

Aerial Photography

Package Delivery

Urban Traffic Reports

Air-taxis

USES OF DRONES

Air mobility company Wisk has been given permission by the New Zealand government to set up and run an air taxi trial in the region of Canterbury.

Drones in NZ need to follow the rules set by the Civil Aviation Authority, https://www.airshare.co.nz/

Cora Air-taxi

Autonomous, electric vertical takeoff and landing aircraft with space for two passengers

SUMMARY

- Artificial intelligence programs solve problems in “intelligent” ways
- Knowledge may be represented in many different ways; choice of representation depends on task
- Neural networks simulate the connectionist structure of the nervous system
- Neural networks are trained to produce the correct responses to inputs
- Robots perform tedious and dangerous tasks
- Drones are unmanned aerial vehicles